Sleep Medicine 15 (2014) 1122–1131

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

U-shaped associations between time in bed and the physical and mental functioning of Japanese civil servants: the roles of work, family, behavioral and sleep quality characteristics

M. Sekine [a,*], T. Tatsuse [a], N. Cable [b], T. Chandola [c], M. Marmot [b]

[a] Department of Epidemiology and Health Policy, University of Toyama, Toyama, Japan
[b] Department of Epidemiology and Public Health, University College London, London, UK
[c] The Cathie Marsh Centre for Census and Survey Research (CCSR), University of Manchester, Manchester, UK

ARTICLE INFO

Article history:
Received 16 December 2013
Received in revised form 5 April 2014
Accepted 7 April 2014
Available online 23 May 2014

Keywords:
Psychosocial stress
Shift work
Socio-economic status
Sleep
Work–family conflict
Work hours

ABSTRACT

Objectives: This study aimed to evaluate (i) whether work, family, behavioral and sleep quality characteristics differ among individuals with different time in bed (TIB), and (ii) whether and how much the U-shaped associations between TIB and health can be explained by these characteristics.
Methods: Participants were 3510 employees (2371 males and 1139 females) aged 20–65 years working in local government in Japan. They completed a questionnaire regarding work, family, and behavioral characteristics. Sleep quality and physical and mental functioning were evaluated using the Pittsburgh Sleep Quality Index and the Short Form 36.
Results: High job demands, long work hours, and high work–family conflict were more prevalent among those with short TIB. Those with long TIB had daily drinking habits. Whereas those with short TIB had poor sleep, mainly due to poor subjective sleep quality and daytime dysfunction, those with long TIB had poor sleep, mainly due to long sleep latency, poor sleep efficiency and sleep disturbances. The U-shaped associations between TIB and poor physical and mental health, with the best health observed in those spending ~8 h in bed, weakened considerably after adjustment for sleep quality, followed by work and family characteristics. After adjusting for behavioral characteristics and long-standing illnesses, the associations hardly changed.
Conclusions: The U-shaped associations between TIB and health may be explained by U-shaped associations between TIB and poor sleep and psychosocial stress in work and family life.

1. Introduction

There is a long history of research on the associations between sleep quantity (i.e. sleep hours) and physical and mental health [1–3]. The accumulated evidence suggests that, in general, the association between sleep hours and health is U-shaped: both short and long sleep hours are associated with an increased risk for deterioration in health, notably the development of cardiovascular disease, depression, and mortality [1–3]. In addition, although these U-shaped associations are more or less reduced after adjustment for a variety of confounding factors, they tend to remain significant, thus indicating that both short and long sleep hours as health risks are statistically independent. Recently, evidence that poor sleep quality (e.g. long sleep latency and poor sleep efficiency) is associated with cardiovascular and all-cause mortality has been accumulating [4,5]. Therefore, the current consensus on the relationship between sleep and health is that obtaining an appropriate sleep quantity with good sleep quality is important for the maintenance of good health. However, there remain several issues to be resolved on the associations between sleep and physical and mental health.

First, because most previous research has focused on whether sleep hours are statistically independent in the relationship between sleep and health, previous studies on the correlates and determinants of sleep hours are relatively limited and primarily focused on whether the socio-economic status, behavioral characteristics, and medical conditions differ among individuals with different sleep hours [6,7]. However, the associations between sleep hours and psychosocial stresses related to work and family life and work hours must be examined because recent changes in sleep hours have occurred concomitant with substantial changes in organizational and

* Corresponding author at: Department of Epidemiology and Health Policy, University of Toyama, Graduate School of Medicine and Pharmaceutical Sciences, 2630 Sugitani, Toyama 930-0194, Japan. Tel.: +81 (0)76 434 7270; fax: +81 (0)76 434 5022.
E-mail address: sekine@med.u-toyama.ac.jp (M. Sekine).

http://dx.doi.org/10.1016/j.sleep.2014.04.012
1389-9457/

personnel management and in female participation in the labor force in the past decades.

Among working populations, habitual late bedtimes and early rising are sometimes unavoidable, reflecting duties at work and home, and working individuals are usually healthier than the general adult population; therefore, sleep habits may be considerably determined by work and family characteristics rather than by the presence or absence of disease. In general, low job control, high job demands, and low social support at work are associated with an increased risk for coronary heart diseases [8], musculoskeletal diseases [9], and depression [10]. Therefore, work and family characteristics are determinants of sleep habits and comprise a potential confounder for the relationship between sleep and health. In our previous study of Japanese civil servants, low job control, high job demands, low social support, and work–family conflicts were found to be determinants of poor sleep quality and poor physical and mental health [11,12]. These work and family characteristics may affect both sleep hours and the association between sleep and health.

Second, the association between sleep hours and sleep quality has been reported to be U-shaped [13,14], which may explain some of the U-shaped associations between sleep hours and physical and mental health. However, research on sleep quality determined by sleep hours in which potential confounders, including age and sex, are taken into consideration has not been fully conducted, and little is known about the degree to which poor sleep quality among short and long sleepers is independent from known risk factors for poor sleep quality. In addition, whereas there are studies on whether work, family, and behavioral characteristics contribute to sleep quality [11,15], the extent to which sleep quality determined by sleep hours may be explained by such characteristics remains unknown. Moreover, sleep quality consists of several components, including subjective sleep quality, sleep latency, sleep efficiency, sleep disturbances, and daytime dysfunction [16]. Comprehensive data on each factor and overall sleep quality determined by sleep hours remain limited.

Third, the research focus of many previous studies has been to evaluate whether sleep hours are statistically independent in the associations between sleep hours and physical and mental health by entering various characteristics simultaneously into multivariate models. Although there is some evidence that the significant associations observed between short sleep hours and all-cause and cardiovascular mortality are reduced and become non-significant after adjusting for stress levels [17], there remain questions as to the more detailed roles of work, family, behavioral, and sleep quality characteristics in explaining the U-shaped association between sleep hours and health. Understanding better the relative strength of contribution of each factor to this U-shaped relationship may assist in determining priorities when implementing different kinds of health policies. There have been few studies on identifying those work, family, and behavioral characteristics most important for weakening the U-shaped relationship between sleep and health.

The purpose of this study was therefore to examine: (i) whether work, family and behavioral characteristics differ among individuals with different time in bed (TIB); (ii) whether sleep quality and physical and mental functioning differ among individuals with different TIB; and (iii) whether and how work, family, and behavioral characteristics contribute to the associations observed between TIB and sleep quality and physical and mental functioning.

2. Methods

2.1. Participants

The Japanese Civil Servants Study (the JACS study) is an international collaborative study conducted in association with the British Civil Servants Study (the Whitehall II study) [11,12,15,18,19]. The participants of this study were civil servants working in the local government of Japan. The participants primarily consisted of clerical workers, professional and technical workers including health care workers, and office support staff. A postal questionnaire was distributed and gathered through the personnel section of the local government department between January and February 2003. After completing the questionnaire, the participants returned it in a sealed envelope to the research team through the personnel section. Altogether, 4272 participants responded (response rate: 79.2%). After excluding the participants without relevant data for this study, 3510 participants (2371 males and 1139 females) comprised the study population. The differences in personal attributes between the study population and the excluded subjects indicated that older subjects and females were slightly underrepresented in this study population. The mean age of the participants was 42.7 years (standard deviation, 10.2).

The JACS study was conducted as a part of the annual health check-ups regulated by the Industrial Safety and Health Law. An ad-hoc committee of the civil service, including ordinary members of the Industrial Safety and Health Committee, personnel section staff, and representatives from labor unions discussed and approved the content and ethical aspects of the study. All participants were informed that they were free to participate or to refuse to participate in the study. Written informed consent was obtained from all participants. All subjects participated voluntarily.

2.2. Questionnaire

The questionnaire items were chosen from among those used in the Whitehall II study. The English questionnaire was translated into Japanese and then translated back into English by a person who had no knowledge of the original questionnaire. The back-translated questionnaire was compared with the original version and accepted by the researchers of the Whitehall II study. In our previous studies, we showed that the questionnaire had acceptable psychometric properties [11,12,18].

2.3. Work characteristics

Among the various work characteristics, the grade of employment, psychosocial stress at work, work hours, and shift work were found to be independently associated with poor sleep and poor physical and mental functioning in our previous study of Japanese civil servants [11,12] and were, therefore, chosen to measure the work characteristics of the participants in the present study.

The grades of employment were ranked hierarchically in the following manner: civil servants with an administrative title and professional equivalence (high-grade employees); and civil servants with no administrative title and professional equivalence (low-grade employees).

Low job control, high job demands, and low social support at work are known to be major psychosocial stress factors at work [8]. In this study, the psychosocial stress factors were evaluated using 25 self-reported items (15 items for control at work, four items for demands at work and six items for social support at work) [8]. The response categories ranged from 0 (often) to 3 (never). After all items had been recorded in the same direction, scores for each scale were calculated by summing the item scores. A higher score for each scale indicates higher control, higher demands, or higher support at work. The reliability coefficient (Cronbach's α [20]) was 0.79 for job control, 0.69 for job demands, and 0.83 for social support at work in this population [12]. This suggests that the questionnaire had moderate-to-high internal consistency. All scales were divided into two groups, high and low stress, using the median score of each scale.

With respect to shift work, the participants were asked whether they engaged in shift work (yes or no). Regarding work hours, the participants coded their work hours in terms of 10 response categories, ranging from <6 h to ≥14 h. The number of work hours was dichotomized [<9 h (regular work hours) versus ≥9 h (long work hours)].

2.4. Family characteristics

Being unmarried, raising young children, and having work–family conflicts were found to be associated with poor sleep quality and physical and mental health in our previous study [11,12] and were, therefore, chosen as family characteristics in this study.

The participants were asked whether they were unmarried (including never married, divorced, separated, or widowed) or married (including cohabiting) and whether they were raising young children (aged <15 years).

The questions regarding family–work conflict consisted of eight items (four items for family-to-work conflict and four items for work-to-family conflict) [21]. Each question had three response categories ranging from 0 (never) to 2 (often). Each scale score was calculated by summing the item score, which ranged from 0 to 8. A high score for each scale indicates a high level of conflict. Both the work-to-family conflict and family-to-work conflict variables were dichotomized into high versus low levels of conflict using the median value of this population. In this population, Cronbach's α was 0.82 for family-to-work conflict and 0.73 for work-to-family conflict [12], implying high internal consistency.

2.5. Behavioral characteristics

Smoking, exercise, and drinking habits have links with sleep quality and physical and mental health [15] and were, therefore, chosen as measurements of the behavioral characteristics of the participants. Smoking habits were rated according to three response alternatives (current smokers, ex-smokers, never smokers) and dichotomized in the analysis (current smokers versus ex-smokers and never smokers). Exercise habits were rated according to four response alternatives, ranging from three times or more per week to almost never, and dichotomized in the analysis (once per month or more versus less than once a month). Drinking habits were rated according to six response alternatives, ranging from almost daily to almost never, and dichotomized in the analysis (almost daily versus four times a week or less).

2.6. Sleep quantity and quality

The Pittsburgh Sleep Quality Index (PSQI) was used to measure sleep quality over the previous month [16]. The PSQI is a self-rated questionnaire consisting of 17 items. A Japanese version of the questionnaire was developed [22] and used in this study. Each item was used to generate seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medications, and daytime dysfunction. Each component score has a range of 0–3. The sum of the seven component scores yields a global PSQI score, which has a range of 0–21. A higher score indicates a lower quality of sleep. This questionnaire has been extensively used to investigate the sleep quality of non-clinical populations and psychiatry patients [23,24]. A cut-off score of >5.5 has a sensitivity of 80.0–85.7% for various patient groups (i.e. those with primary insomnia, major depression, general anxiety disorder, and schizophrenia) and a specificity of 86.6% for control subjects in the Japanese version of the PSQI [24]. Subjects with a PSQI global score of >5.5 were defined as having poor sleep quality. Cronbach's α, a measure of internal consistency, was 0.62 for the global score in this population [11], suggesting that the score had an acceptable level of internal consistency.

The PSQI questions ask the participants to describe their bedtime and rising time in hours and minutes. Using the bedtime and rising time, time in bed (TIB) was calculated. Participants spending <5 h in bed and those spending ≥9 h in bed were very few (<3% of participants for each category) so the amount of TIB was divided into six categories, ranging from <5 h to ≥9 h. It has been pointed out that, in previous epidemiological studies, sleep hours often mean TIB [25,26]. The sleep duration component of the PSQI is defined as actual sleep, which reflects the hours spent in bed, sleep latency, and night awakenings. Bedtime was divided into two categories (early bedtimes for those with a bedtime before 00:00 versus late bedtimes for those with a bedtime at 00:00 or later). The rising time was divided into two categories (early rising for those with a rising time before 06:00 versus late rising for those with a rising time at 06:00 or later).

2.7. Physical and mental functioning

Physical and mental functioning was evaluated using the Medical Outcome Survey Short Form 36 (SF-36) [27,28]. A Japanese version of the SF-36 was developed [29–31] and used in this study. The questionnaire items were used to generate eight subscales: physical functioning (PF); role – physical (RP); bodily pain (BP); general health perception (GH); vitality (VT); social functioning (SF); role – emotional (RE); and mental health (MH). The subscale scores were standardized according to the general US population to generate a corresponding *z*-score. Aggregate physical and mental component scores of the SF36 (the PCS and the MCS, respectively) were obtained by multiplying each *z*-score by its respective physical and mental factor score coefficient and summing the eight products. Finally, each aggregate component score was transformed to the norm-based score with a population mean of 50 and a standard deviation of 10. Higher scores represent better physical and mental functioning. In this study, participants in the lowest quartile of the scale were considered to have poor physical and mental functioning. Cronbach's α for the Japanese version ranged from 0.71 to 0.91 [31]. The test–retest reliability ranged from 0.78 to 0.86 [31].

2.8. Long-standing illnesses

Long-standing illnesses may affect TIB and are associated with an increased risk of poor physical and mental functioning. Therefore, the health status is a potential confounder for the relationships between TIB and physical and mental health. The subjects were asked to answer 'yes' or 'no' to a question regarding whether they had any long-standing illnesses. A positive answer was associated with the presence of various doctor-diagnosed physical and mental diseases in this population.

2.9. Statistical analysis

The age-standardized percentages of work, family and behavioral characteristics and long-standing illnesses according to TIB were calculated using 10-year age groups of participants spending 7–8 h in bed as the standard population. The χ^2-test was used to evaluate whether work, family, and behavioral characteristics differed among the participants with different TIB. For work, family and behavioral characteristics that significantly differed among participants with different TIB, the adjusted residual was calculated to evaluate whether the observed percentage of those with undesirable work, family, and behavioral characteristics by TIB significantly differed from the expected percentage.

To evaluate whether there were differences in the PSQI components and global scores among the participants with different TIB,

analysis of covariance (ANCOVA) was performed using age as covariate. For multiple comparisons, Bonferroni's test was used to assess differences in the scores between any two categories of TIB.

A logistic regression analysis was performed to examine (i) whether the frequencies of poor sleep and poor physical and mental functioning differ among those with different TIB and (ii) how much the association between TIB and health can be explained by work, family, and behavioral characteristics. The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. The Hosmer–Lemeshow test [32] was used to validate the multivariate models. Multicollinearity in the models was assessed using the tolerance and variance inflation factor (VIF) statistics. A tolerance value <0.10 and VIF value >10 indicate multicollinearity in the data [33]. The Sobel test was performed to evaluate whether the associations of TIB with physical and mental functioning were mediated by poor sleep quality [34].

The statistical analyses were performed using the SPSS software program (18.0.J, SPSS, Inc., Chicago, IL, USA). Two-tailed $P < 0.05$ was considered significant. The statistical analyses were performed separately according to sex.

3. Results

Table 1 shows the characteristics of the participants by sex. The females were younger than the males and had more stressful work and family characteristics and undesirable behavioral characteristics, including a low employment grade, low job control, high job demands, long work hours, shift work, unmarried status, high level of work-to-family conflict, high level of family-to-work conflict, and a lack of exercise habits. Raising young children, current smoking, and daily alcohol drinking were more often observed among males than females. Females tended to be late bedtimers and early risers and had short TIB, worse PSQI global scores, and higher prevalence of poor sleep quality than males. Whereas the PCS and MCS were lower among females than males, the prevalence of long-standing illnesses was higher among males than females.

Table 2 shows age-standardized work, family, and behavioral characteristics according to TIB. In both males and females, health risk factors were more prevalent among those with short TIB: high job demands, long work hours, unmarried status, high level of work-to-family conflict, and high level of family-to-work conflict were more frequently observed among those with short TIB than among those with long TIB. The association between short TIB and low job control was marginally significant. Current smoking rates were higher among those with short TIB than among those with long TIB; however, this association was not statistically significant. Those with short TIB tended to be late bedtimers and early risers, whereas the opposite was true for those with long TIB.

In both males and females, those with long TIB were more likely to drink alcohol daily. The association of raising young children and TIB was U-shaped. There were no significant associations between TIB and exercise habits. Whereas those with long TIB tended to have low social support in males, this association was U-shaped in females. Therefore, in both males and females, whereas those with short TIB and, to a lesser degree, those with long TIB have health risk factors, the types of health risk factors differ between those with short and long TIB.

Table 3 shows the age-adjusted PSQI components and global scores by TIB. In both males and females, there were U-shaped associations between TIB and the PSQI global score and prevalence of poor sleep quality: both those with short and long TIB had a higher prevalence of poor sleep quality than those spending 7–8 h in bed for males and 8–9 h in bed for females with the lowest prevalence of poor sleep quality (15.4% for males and 15.8% for females). In addition, the reasons for poor sleep quality differed between those with short and long TIB, particularly among males: those with short TIB had poor sleep quality primarily attributable to poor subjective sleep quality, short sleep duration, and daytime dysfunction, whereas those with long TIB had poor sleep quality primarily attributable to long sleep latency, low habitual sleep efficiency, and sleep disturbances. There were no significant associations between TIB and the use of sleep medications. Therefore, males spending 7–8 h in bed and females spending 8–9 h in bed did not have the best scores in each of the PSQI components, although they had the best mix of components in terms of the prevalence of poor sleep quality as estimated according to the PSQI global score.

Table 4 shows poor sleep quality (the PSQI global score >5.5) according to TIB, before and after adjustment for work, family, and behavioral characteristics. In comparison with those spending 7–8 h in bed, the OR of those spending 5 h in bed for poor sleep quality was 18.7 (8.32–42.0) for males and 7.93 (3.68–17.1) for females in the age-adjusted model (model 1). After adjusting for all of the characteristics (model 6), the ORs were considerably reduced to 13.4 (5.76–31.4) for males and 5.94 (2.65–13.3) for females. Work and family characteristics contributed more to this reduction than behavioral characteristics and long-standing illnesses. The age-adjusted OR of those with long TIB for poor sleep quality hardly changed after adjustment for work, family and behavioral characteristics, and long-standing illnesses.

Table 1
Characteristics of the participants by sex.

Characteristics		Males (%) ($n = 2371$)	Females (%) ($n = 1137$)	P-value (χ^2-test)
Age group (years)				
≤24		0.8	6.3	
25–34		23.2	32.7	
35–44		27.6	24.6	
45–54		34.4	25.5	
≥55		14.0	11.0	<0.001
Work characteristics				
Employment grade	Low	65.3	85.1	<0.001
Control	Low	46.6	59.0	<0.001
Demand	High	36.1	50.7	<0.001
Support	Low	52.3	51.0	0.489
Work hours	Long	28.4	38.5	<0.001
Shift work	Yes	8.3	46.2	<0.001
Family characteristics				
Marital status	Unmarried	18.4	33.8	<0.001
Young children	Yes	35.0	26.8	<0.001
Work-to-family conflict	High	35.4	51.8	<0.001
Family-to-work conflict	High	30.7	46.9	<0.001
Behavioral characteristics				
Exercise	No	46.3	66.5	<0.001
Smoking	Current	34.8	6.1	<0.001
Alcohol drinking	Daily	37.6	8.6	<0.001
Sleep characteristics				
Time in bed (h)				
<5		1.5	2.9	
5–6		7.3	13.3	
6–7		28.5	40.0	
7–8		43.0	33.4	
8–9		17.0	8.9	
≥9		2.7	1.5	<0.001
Bedtime	Late	30.7	34.9	0.015
Rising	Early	16.9	27.2	<0.001
PSQI global score[a]		3.90 (2.37)	4.64 (2.51)	<0.001
Sleep quality	Poor	21.3	31.6	<0.001
Health Status (SF-36)				
PCS[a]		50.2 (6.26)	48.7 (7.40)	<0.001
MCS[a]		47.0 (9.76)	43.8 (10.8)	<0.001
Long-standing illness	Yes	35.7	29.6	<0.001

PSQI, Pittsburgh Sleep Quality Index; SF-36, Short Form 36; PCS, physical component summary scale; MCS, mental component summary scale.
[a] Values are mean (standard deviation).

Table 2
Age-standardized work, family and behavioral characteristics by time in bed.

Characteristics		Time in bed (h)						χ^2-Test		Adjusted residual	
		<5 (a)	5–6 (b)	6–7 (c)	7–8 (d)	8–9 (e)	≥9 (f)	Pearson's *P*	*P* for trend	O < E	E < O
Males (*n* = 2371)											
Age	>45 years (%)	17.1	27.0	43.0	50.9	60.0	66.2	<0.001	<0.001	a, b, c	d, e, f
Work characteristics											
Grades of employment	Low (%)	59.7	62.4	62.2	62.4	66.8	75.2	0.219	0.055		
Control	Low (%)	45.4	42.6	43.9	48.5	47.2	39.3	0.334	0.284		
Demands	High (%)	42.7	46.6	42.5	32.6	27.9	26.8	<0.001	<0.001	d, e	b, c
Social support	Low (%)	34.6	48.5	52.8	53.4	53.4	52.8	0.239	0.090		
Work hours	Long (%)	40.4	41.6	37.8	23.2	16.0	14.8	<0.001	<0.001	d, e	b, c
Shift work	Yes (%)	14.3	7.8	7.4	8.1	11.4	6.2	0.180	0.372		
Family characteristics											
Young children	Yes (%)	35.5	27.7	32.9	35.9	41.1	33.0	0.025	0.005	b	e
Marital status	Unmarried (%)	23.8	29.9	21.8	13.0	13.0	13.9	<0.001	<0.001	d, e	b, c
Work-to-family conflict	High (%)	55.9	33.6	36.0	27.9	23.9	32.7	<0.001	<0.001	d, e	b, c
Family-to-work conflict	High (%)	52.3	30.0	37.2	36.9	30.0	41.9	0.014	0.329	e	a
Behavioral characteristics											
Exercise	No (%)	40.7	49.5	48.0	44.8	46.0	52.2	0.576	0.742		
Smoking	Current (%)	41.2	35.9	30.4	34.9	38.2	38.6	0.123	0.090		
Alcohol drinking	Daily (%)	16.9	23.7	33.2	38.0	48.6	62.0	<0.001	<0.001	a, b, c	e, f
Bedtime	Late (%)	83.5	83.5	54.4	14.3	0.2	2.9	<0.001	<0.001	d, e, f	a, b, c
Rising	Early (%)	42.2	33.5	24.7	13.6	9.6	2.4	<0.001	<0.001	d, e, f	a, b, c
Long-standing illness	Yes (%)	35.6	37.5	35.9	35.8	36.0	50.6	0.291	0.411		
Females (*n* = 1139)											
Age	>45 years (%)	42.4	38.8	38.6	35.3	28.7	17.6	0.205	0.018		
Work characteristics											
Grades of employment	Low (%)	83.2	81.1	86.9	85.5	87.8	70.3	0.212	0.498		
Control	Low (%)	85.1	57.8	57.5	59.2	61.6	56.2	0.079	0.496		
Demands	High (%)	63.1	53.6	53.7	45.3	46.3	66.2	0.050	0.030	d	
Social support	Low (%)	71.5	46.6	51.9	47.9	51.8	71.4	0.041	0.642		a
Work hours	Long (%)	47.9	50.3	41.0	33.7	33.7	28.7	0.001	<0.001	d, e	b
Shift work	Yes (%)	37.9	45.6	45.3	45.3	54.7	66.2	0.297	0.082		
Family characteristics											
Young children	Yes (%)	27.3	14.2	23.7	28.2	36.7	38.0	0.002	<0.001	b	e
Marital status	Unmarried (%)	46.5	41.5	37.8	34.2	27.1	15.6	0.060	0.002	e	
Work-to-family conflict	High (%)	51.9	53.2	48.6	42.6	40.6	41.2	0.161	0.008		
Family-to-work conflict	High (%)	57.4	53.0	52.5	45.3	51.9	43.6	0.260	0.070		
Behavioral characteristics											
Exercise	No (%)	71.0	71.2	64.1	63.9	72.9	67.7	0.309	0.949		
Smoking	Current (%)	8.9	8.6	6.4	5.3	4.8	0.0	0.559	0.065		
Alcohol drinking	Daily (%)	8.3	9.1	5.5	9.2	18.2	29.8	<0.001	0.001	c	e, f
Bedtime	Late (%)	93.5	82.3	46.7	9.7	1.6	7.7	<0.001	<0.001	d, e, f	a, b, c
Rising	Early (%)	43.5	44.4	32.2	15.5	10.1	0.0	<0.001	<0.001	d, e, f	a, b, c
Long-standing illness	Yes (%)	38.8	32.0	31.2	25.0	26.9	39.2	0.163	0.077		

O < E, the observed percentage of participants with a particular characteristic was significantly below the expected percentage; E < O, the observed percentage was significantly above the expected percentage.

Table 5 shows poor physical functioning according to TIB, before and after adjustment for work, family, behavioral and sleep quality characteristics, and long-standing illnesses. The association between TIB and poor PCS was U-shaped. In the age-adjusted model (model 1), the OR of those spending <5 h in bed for poor PCS was 1.77 (0.85–3.69) for males and 1.72 (0.82–3.61) for females. After adjusting for all of the characteristics and long-standing illnesses (model 7), the ORs were reduced considerably to 0.78 (0.34–1.75) for males and 0.92 (0.40–2.11) for females. The sleep quality characteristics contributed the most to this reduction (model 5), followed by work and family characteristics (models 2 and 3). Behavioral characteristics and long-standing illnesses hardly contributed to the reduction (models 4 and 6). Meanwhile, the age-adjusted OR of those spending ≥9 h in bed for poor PCS was 1.35 (0.77–2.35) for males and 1.24 (0.43–3.63) for females. After making adjustments for various characteristics, the ORs were mildly reduced to 1.05 (0.58–1.90) for males and 1.07 (0.34–3.40) for females.

Table 6 shows poor mental functioning according to TIB, before and after adjustment for work, family, behavioral, and sleep quality characteristics and long-standing illnesses. The association between TIB and poor MCS was U-shaped for males, whereas only those with short TIB were more likely to have poor MCS among females. In the age-adjusted model (model 1), the OR of those spending <5 h in bed for poor MCS was 5.45 (2.73–10.9) for males and 1.93 (0.93–3.99) for females. After adjusting for all of the characteristics and long-standing illness (model 7), the ORs were reduced considerably to 1.59 (0.68–3.69) for males and 0.61 (0.26–1.40) for females. The sleep quality characteristics contributed the most to this reduction (model 5), followed by work and family characteristics (models 2 and 3). The age-adjusted OR of those spending ≥9 h in bed for poor MCS was 2.97 (1.76–5.04) for males and 0.77 (0.25–2.42) for females. Making adjustments for various characteristics hardly changed the ORs.

The Hosmer–Lemeshow tests validated the results of the final logistic regression models (i.e. model 6 in Table 4 and model 7 in Tables 5 and 6). The correlation coefficients of the independent variables used in the logistic regression analysis (i.e. TIB, age, work characteristics, family characteristics, behavioral characteristics, long-standing illness, and poor sleep quality as measured using the PSQI global score) ranged from −0.54 to 0.44. When TIB and poor sleep quality were simultaneously entered, the tolerance statistics were 0.997 for males and 0.995 for females and the VIF statistics were 1.003 for males and 1.005 for females. In the final logistic regression models, the tolerance statistics ranged from 0.485 to 0.986 and

Table 3
Age-adjusted Pittsburgh Sleep Quality Index components and global scores by time in bed.

Components	Time in bed (h)						ANCOVA	Multiple comparisons
	<5 (a)	5–6 (b)	6–7 (c)	7–8 (d)	8–9 (e)	≥9 (f)	*P*-value	
Males ($n = 2371$)								
Subjective sleep quality	1.59 (0.10)	1.21 (0.05)	1.14 (0.02)	1.10 (0.02)	1.14 (0.03)	1.10 (0.08)	<0.001	a > b, c, d, e, f
Sleep latency	0.62 (0.13)	0.60 (0.06)	0.64 (0.03)	0.71 (0.02)	0.78 (0.04)	0.87 (0.10)	0.012	e > c
Sleep duration	2.65 (0.07)	1.82 (0.03)	0.97 (0.02)	0.21 (0.01)	0.09 (0.02)	0.17 (0.05)	<0.001	a > b, c, d, e, f; b > c, d, e, f; c > d, e, f; d > e
Habitual sleep efficiency	0.00 (0.06)	0.05 (0.03)	0.06 (0.01)	0.06 (0.01)	0.14 (0.02)	0.64 (0.04)	<0.001	a < f; b < f; c < e, f; d < e, f; e < f
Sleep disturbances	0.68 (0.09)	0.54 (0.04)	0.61 (0.02)	0.65 (0.02)	0.73 (0.03)	0.79 (0.07)	<0.001	b < e, f; c < e
Use of sleep medication	0.11 (0.07)	0.03 (0.03)	0.05 (0.02)	0.08 (0.01)	0.11 (0.02)	0.11 (0.05)	0.179	
Daytime dysfunction	1.60 (0.13)	0.89 (0.06)	0.79 (0.03)	0.64 (0.02)	0.60 (0.04)	0.57 (0.09)	<0.001	a > b, c, d, e, f; b > d, e; c > d, e
Global score	7.25 (0.39)	5.13 (0.17)	4.26 (0.09)	3.44 (0.07)	3.60 (0.11)	4.25 (0.28)	<0.001	a > b, c, d, e, f; b > c, d, e; c > d, e
Prevalence of poor sleep	77.1	37.9	25.3	15.4	16.9	23.1		
Females ($n = 1139$)								
Subjective sleep quality	1.43 (0.10)	1.29 (0.05)	1.24 (0.03)	1.11 (0.03)	1.08 (0.06)	1.04 (0.15)	<0.001	b > e; c > d
Sleep latency	0.85 (0.15)	0.88 (0.07)	0.80 (0.04)	0.88 (0.05)	0.81 (0.09)	0.75 (0.21)	0.784	
Sleep duration	2.43 (0.09)	1.82 (0.04)	1.01 (0.02)	0.27 (0.03)	0.14 (0.05)	0.23 (0.12)	<0.001	a > b, c, d, e, f; b > c, d, e, f; c > d, e, f
Habitual sleep efficiency	0.03 (0.06)	0.02 (0.03)	0.08 (0.02)	0.07 (0.02)	0.18 (0.04)	0.76 (0.08)	<0.001	a < f; b < e, f; c < f; d < f; e < f
Sleep disturbances	0.64 (0.09)	0.78 (0.04)	0.69 (0.03)	0.74 (0.03)	0.77 (0.05)	0.70 (0.13)	0.388	
Use of sleep medication	0.09 (0.07)	0.03 (0.03)	0.08 (0.02)	0.07 (0.02)	0.10 (0.04)	0.25 (0.09)	0.282	
Daytime dysfunction	1.21 (0.14)	1.07 (0.07)	0.98 (0.04)	0.80 (0.04)	0.64 (0.08)	0.82 (0.20)	<0.001	a > e; b > d, e; c > d, e
Global score	6.68 (0.42)	5.88 (0.19)	4.87 (0.11)	3.94 (0.12)	3.71 (0.24)	4.54 (0.58)	<0.001	a > c, d, e, f; b > c, d, e; c > d, e
Prevalence of poor sleep	66.7	53.3	34.6	20.5	15.8	29.4		

Analysis of covariance (ANCOVA) was performed to evaluate the differences in scores between groups with different time in bed, using age and long-standing illness as covariates. Bonferroni's test was performed for multiple comparisons. The data are presented as the adjusted mean (standard error). '<' indicates that Bonferroni's test was significant ($P < 0.05$).

the VIF statistics ranged from 1.014 to 2.063, indicating that the findings observed in the models may not be explained by multicollinearity. The Sobel test indicated that the associations of TIB with poor physical and mental functioning were significantly mediated by poor sleep quality (the proportion mediated, 17.8–48.3%).

4. Discussion

This study showed that both those with short and long TIB have stressful work and family characteristics and undesirable behavioral characteristics. The association between TIB and poor sleep quality was U-shaped, with the lowest prevalence of poor sleep quality observed among those spending ~8 h in bed. The associations between TIB and poor physical and mental functioning were also U-shaped, with one exception – in females, only those with short TIB had poor mental functioning. The strengths of the associations between short and long TIB and poor health were reduced considerably after adjustment for work, family, behavior, and sleep quality characteristics. Among the various characteristics, the sleep quality characteristics contributed most to the reduction, followed by work and family characteristics. The behavioral characteristics and long-standing illnesses hardly contributed to the U-shaped relationship with health.

4.1. U-shaped associations between TIB and work, family, and behavioral characteristics

In this study, those with short TIB had various psychosocial stress factors related to working and family life, including high job demands, long work hours, work-to-family conflict, and family-to-work conflict. In addition, being unmarried was more often observed among those with short TIB. Daily drinking was more frequent among those with long TIB. Therefore, both those with short and long TIB have health risk factors; however, the types of risks differed between those with short and long TIB in this study.

With respect to psychosocial stress, Ikehara et al. [35]. reported, in a large community study conducted in Japan, that high perceived mental stress, as evaluated by a single-item measure, was often experienced among short sleepers. With respect to behavioral characteristics, Ikehara et al. reported no consistent patterns in the associations between sleep hours and behavioral characteristics. Ohayon [36] reported that both short and long sleepers did not tend to have exercise habits among the elderly populations of several European countries. Hicks and Youmans [37] reported that short sleepers tend to consume food, whereas long sleepers tend to consume alcohol. With respect to long-standing illnesses, Patel [6] reported that long sleepers tend to have physical and mental disorders, such as hypertension, diabetes, and depression. Kripke et al. [13] reported that, among postmenopausal females, there are U-shaped associations between sleep hours and various behavioral characteristics (cigarette smoking, activity, and alcohol), income, and marital status.

The findings of previous studies are not necessarily consistent in terms of the association between sleep hours and each of these characteristics. The differences in the findings of previous studies may be partly attributable to sociodemographic, occupational, measurement, and country differences. However, the findings of previous studies are consistent in that both those with short and long TIB have health risk factors. In this sense, the findings of this study are consistent with the existing data.

4.2. U-shaped association between TIB and sleep quality

In this study, whereas those with short and long TIB had sleep problems, the characteristics of poor sleep quality differed between those with short and long TIB: the shorter the TIB, the worse the subjective sleep quality and daytime dysfunction, while the longer the TIB, the worse the sleep latency, sleep disturbance, and habitual sleep efficiency. Both those with short and long TIB tended to use sleep medications but the associations were not statistically significant.

Table 4
Poor sleep quality (PSQI global score >5.5) by time in bed before and after adjustment for various characteristics.

Time in bed (h)	Prevalence of poor sleep (%)	Model 1[a] (age-adjusted)	Model 2[b] (model 1 + work)	Model 3[c] (model 1 + family)	Model 4[d] (model 1 + behavior)	Model 5[e] (model 1 + illness)	Model 6[f] (fully adjusted)
Males (n = 2371)							
<5	77.1	18.7 (8.32–42.0)	16.4 (7.17–37.5)	14.5 (6.31–33.3)	18.0 (7.95–40.7)	18.6 (8.22–41.9)	13.4 (5.76–31.4)
5–6	37.9	3.38 (2.37–4.81)	3.31 (2.30–4.76)	3.35 (2.32–4.85)	3.30 (2.31–4.71)	3.42 (2.40–4.90)	3.35 (2.29–4.91)
6–7	25.3	1.87 (1.46–2.38)	1.80 (1.40–2.30)	1.71 (1.33–2.20)	1.84 (1.44–2.35)	1.88 (1.47–2.41)	1.73 (1.33–2.24)
7–8	15.4	1.00	1.00	1.00	1.00	1.00	1.00
8–9	16.9	1.11 (0.81–1.52)	1.14 (0.83–1.57)	1.20 (0.87–1.66)	1.13 (0.82–1.55)	1.11 (0.81–1.52)	1.24 (0.89–1.72)
≥9	23.1	1.64 (0.90–3.00)	1.73 (0.94–3.18)	1.54 (0.83–2.87)	1.68 (0.91–3.09)	1.50 (0.82–2.75)	1.53 (0.81–2.88)
Females (n = 1139)							
<5	66.7	7.93 (3.68–17.1)	6.74 (3.06–14.8)	6.97 (3.17–15.3)	7.75 (3.58–16.8)	7.60 (3.50–16.5)	5.94 (2.65–13.3)
5–6	53.3	4.48 (2.98–6.71)	4.50 (2.96–6.83)	4.23 (2.78–6.43)	4.35 (2.90–6.54)	4.36 (2.90–6.57)	4.18 (2.71–6.44)
6–7	34.6	2.07 (1.51–2.84)	2.06 (1.49–2.85)	1.93 (1.40–2.66)	2.06 (1.50–2.83)	2.01 (1.46–2.76)	1.88 (1.35–2.62)
7–8	20.5	1.00	1.00	1.00	1.00	1.00	1.00
8–9	15.8	0.72 (0.40–1.29)	0.70 (0.38–1.27)	0.68 (0.37–1.23)	0.70 (0.39–1.27)	0.71 (0.39–1.28)	0.66 (0.34–1.17)
≥9	29.4	1.55 (0.60–4.53)	1.48 (0.49–4.43)	1.68 (0.56–5.02)	1.58 (0.54–4.64)	1.54 (0.52–4.53)	1.65 (0.54–4.99)

PSQI, Pittsburgh Sleep Quality Index.
Values for models 1–6 are expressed as odds ratio (95% confidence interval).
[a] Adjusted for age.
[b] Adjusted for age and work characteristics (grade of employment, control, demand, support, work hours, shift work).
[c] Adjusted for age and family characteristics (children, marital status, work-to-family conflict, family-to-work conflict).
[d] Adjusted for age and behavioral characteristics (exercise, smoking, alcohol drinking).
[e] Adjusted for age and long-standing illness.
[f] Adjusted for age, work, family characteristics, behavioral characteristics, and long-standing illness.

Table 5
Poor physical functioning by time in bed before and after adjustment for various characteristics.

Time in bed (h)	Prevalence of poor PCS (%)	Model 1[a] (age-adjusted)	Model 2[b] (model 1 + work)	Model 3[c] (model 1 + family)	Model 4[d] (model 1 + behavior)	Model 5[e] (model 1 + poor sleep)	Model 6[f] (model 1 + illness)	Model 7[g] (fully adjusted)
Males (n = 2371)								
<5	31.4	1.77 (0.85–3.69)	1.37 (0.64–2.90)	1.39 (0.65–2.95)	1.70 (0.80–3.58)	0.93 (0.43–1.97)	1.64 (0.77–3.50)	0.78 (0.34–1.75)
5–6	22.4	1.08 (0.73–1.59)	0.99 (0.66–1.47)	1.16 (0.77–1.73)	1.07 (0.72–1.58)	0.83 (0.55–1.24)	1.08 (0.72–1.61)	0.91 (0.59–1.40)
6–7	19.7	0.86 (0.68–1.10)	0.80 (0.62–1.02)	0.83 (0.65–1.06)	0.85 (0.67–1.09)	0.76 (0.59–0.97)	0.86 (0.67–1.10)	0.73 (0.56–0.96)
7–8	22.6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8–9	22.3	0.96 (0.77–2.54)	0.98 (0.74–1.30)	1.03 (0.78–1.37)	0.93 (0.70–1.24)	0.94 (0.71–1.24)	0.95 (0.71–1.26)	0.99 (0.73–1.34)
≥9	29.2	1.35 (0.77–2.35)	1.40 (0.79–2.46)	1.29 (0.73–2.28)	1.29 (0.74–2.23)	1.25 (0.70–2.20)	1.12 (0.63–1.99)	1.05 (0.58–1.90)
Females (n = 1139)								
<5	39.4	1.72 (0.82–3.61)	1.42 (0.66–3.03)	1.53 (0.71–3.29)	1.68 (0.80–3.54)	1.09 (0.51–2.33)	1.52 (0.71–3.27)	0.92 (0.40–2.11)
5–6	36.8	1.57 (1.05–2.35)	1.55 (1.02–2.34)	1.34 (0.88–2.04)	1.52 (1.01–2.29)	1.13 (0.74–1.72)	1.47 (0.97–2.22)	0.99 (0.62–1.56)
6–7	32.0	1.27 (0.94–1.71)	1.22 (0.89–1.66)	1.16 (0.85–1.58)	1.24 (0.91–1.68)	1.09 (0.80–1.49)	1.18 (0.86–1.61)	0.95 (0.68–1.33)
7–8	26.8	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8–9	29.7	1.19 (0.73–1.94)	1.15 (0.70–1.88)	1.17 (0.72–1.94)	1.20 (0.73–1.97)	1.27 (0.77–2.08)	1.17 (0.71–1.93)	1.18 (0.69–2.20)
≥9	29.4	1.24 (0.43–3.63)	1.04 (0.34–3.11)	1.32 (0.44–3.92)	1.27 (0.43–3.74)	1.13 (0.37–3.44)	1.21 (0.40–3.67)	1.07 (0.34–3.40)

PCS, physical component summary scale of the Short-Form 36.
Values for models 1–7 are expressed as odds ratio (95% confidence interval).
[a] Adjusted for age.
[b] Adjusted for age and work characteristics (grade of employment, control, demand, support, work hours, shift work).
[c] Adjusted for age and family characteristics (children, marital status, work-to-family conflict, family-to-work conflict).
[d] Adjusted for age and behavioral characteristics (exercise, smoking, alcohol drinking).
[e] Adjusted for age and poor sleep quality as measured using the Pittsburg Sleep Quality Index global score.
[f] Adjusted for age and long-standing illness.
[g] Adjusted for age, work, family and behavioral characteristics, poor sleep quality, and long-standing illness.

Table 6
Poor mental functioning by time in bed before and after adjustment for various characteristics.

Time in bed (h)	Prevalence of poor MCS (%)	Model 1[a] (age-adjusted)	Model 2[b] (model 1 + work)	Model 3[c] (model 1 + family)	Model 4[d] (model 1 + behavior)	Model 5[e] (model 1 + poor sleep)	Model 6[f] (model 1 + illness)	Model 7[g] (fully adjusted)
Males ($n = 2371$)								
<5	57.1	5.45 (2.73–10.9)	4.06 (1.95–8.47)	3.48 (1.63–7.42)	5.39 (2.69–10.8)	2.26 (1.08–4.72)	5.33 (2.66–10.7)	1.59 (0.68–3.69)
5–6	19.5	1.02 (0.67–1.53)	0.86 (0.56–1.31)	0.95 (0.61–1.48)	1.00 (0.66–1.52)	0.65 (0.42–1.01)	1.02 (0.68–1.54)	0.65 (0.40–1.03)
6–7	22.7	1.29 (1.01–1.64)	1.14 (0.88–1.46)	1.10 (0.85–1.43)	1.27 (1.00–1.62)	1.08 (0.84–1.40)	1.29 (1.02–1.65)	0.90 (0.68–1.19)
7–8	18.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8–9	22.1	1.32 (0.99–1.75)	1.45 (1.08–1.95)	1.58 (1.16–2.15)	1.32 (0.99–1.76)	1.31 (0.97–1.77)	1.32 (0.99–1.75)	1.65 (1.19–2.29)
≥9	38.5	2.97 (1.76–5.04)	3.52 (2.04–6.07)	3.13 (1.75–5.61)	2.97 (1.74–5.05)	2.87 (1.65–5.01)	2.80 (1.65–4.76)	3.23 (1.75–5.95)
Females ($n = 1139$)								
<5	42.4	1.93 (0.93–3.99)	1.31 (0.61–2.81)	1.48 (0.68–3.21)	1.87 (0.90–3.09)	0.91 (0.42–2.00)	1.85 (0.89–3.83)	0.61 (0.26–1.40)
5–6	42.1	1.89 (1.28–2.81)	1.69 (1.12–2.55)	1.59 (1.05–2.41)	1.84 (1.24–2.73)	1.13 (0.73–1.73)	1.85 (1.24–2.74)	0.92 (0.58–1.46)
6–7	34.2	1.35 (1.01–1.82)	1.24 (0.91–1.69)	1.19 (0.87–1.63)	1.35 (1.00–1.82)	1.07 (0.78–1.47)	1.32 (0.98–1.78)	0.91 (0.64–1.27)
7–8	27.9	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8–9	23.8	0.80 (0.48–1.33)	0.81 (0.48–1.39)	0.78 (0.46–1.34)	0.77 (0.46–1.29)	0.86 (0.50–1.47)	0.79 (0.47–1.32)	0.89 (0.50–1.57)
≥9	23.5	0.77 (0.25–2.42)	0.73 (0.22–2.40)	1.01 (0.31–3.28)	0.77 (0.25–2.43)	0.64 (0.19–2.15)	0.76 (0.24–2.40)	0.82 (0.22–3.02)

MCS, mental component summary scale of the Short-Form 36.
Values for models 1–7 are expressed as odds ratio (95% confidence interval).
[a] Adjusted for age.
[b] Adjusted for age and work characteristics (grade of employment, control, demand, support, work hours, shift work).
[c] Adjusted for age and family characteristics (children, marital status, work-to-family conflict, family-to-work conflict).
[d] Adjusted for age and behavioral characteristics (exercise, smoking, alcohol drinking).
[e] Adjusted for age and poor sleep quality as measured using the Pittsburg Sleep Quality Index global score.
[f] Adjusting for age and long-standing illness.
[g] Adjusted for age, work, family and behavioral characteristics, poor sleep quality, and long-standing illness.

Those with average TIB, spending ~8 h in bed, did not obtain the best sleep in terms of each component of the PSQI: those with average TIB had worse sleep than those with long TIB in terms of subjective sleep and daytime dysfunction, and worse sleep than those with short TIB in terms of sleep latency and habitual sleep efficiency. However, those with average TIB had a more balanced and moderate sleep quality than those with short and long TIB, leading them to have the best overall sleep quality and lowest prevalence of poor sleep.

The findings of previous studies are somewhat different but appear to agree that both short and long sleepers have poor sleep quality. Grandner and Kripke [14] showed that all of the sleep quality components, including difficulty falling asleep, waking during the night, waking too early, waking unrefreshed, and daytime sleepiness, are best among those sleeping ~8 h. Morin et al. [38]. reported that long sleep hours are associated with midnight awakening and prolonged sleep onset latency. Ohayon [36] also reported an association between sleep hours and sleep quality in the general populations of seven European countries: whereas both short and long sleepers had sleep disturbances and were more likely to use sleep medications, short sleepers more frequently experienced early morning awakening and difficulty falling asleep.

The somewhat inconsistent findings of previous studies and this study may be partly attributable to differences in sociodemographic characteristics, measurements and statistical methods. For example, whereas the majority of the participants in a previous study [36] were retired elderly individuals whose shortened sleep may have been caused not by duties in work and family life (i.e. extrinsic factors), but by the nature of their sleep (i.e. intrinsic factors), all of the participants in this study were working and often had a spouse and young children; therefore, their shortened TIB may have resulted from sleep deprivation due to duties at work and home, and they required more TIB in order to maintain their daytime function. Those with long TIB in this study tended to drink alcohol daily, which may reflect that they have long sleep latency and want to fall asleep shortly, leading them to poor overall sleep quality due to sleep fragmentation and poor sleep efficiency. The above-mentioned pathways are biologically plausible.

In this study, the strength of the association between short TIB and poor sleep quality was considerably reduced after adjustment for work and family characteristics. This change may be explained by the fact that stressful work and family characteristics were more prevalent among those with short TIB than among those with average and long TIB in this study, and that stressful characteristics were found to be strongly associated with poor sleep quality in our previous study of Japanese civil servants [11].

In contrast, making adjustments for behavioral characteristics and long-standing illnesses hardly changed the association between short TIB and poor sleep quality in this study. This can be explained by the fact that, although behavioral characteristics and long-standing illnesses were found to be associated with poor sleep quality in our previous study of Japanese civil servants [11,15], there were no consistent patterns in the associations between TIB and long-standing illnesses and behavioral characteristics, except for alcohol drinking habits.

Overall, the findings of this study are consistent with, and can be explained by, the existing data. Our contribution to the relevant literature is that ~8 h of TIB may result not in the best in all of the sleep quality components, but rather in the best mix of the components, leading to the lowest prevalence of poor overall sleep quality. Another important finding is that poor sleep quality, particularly among those with short TIB, may be explained by the accumulation of disadvantaged work and family characteristics among those with short TIB. However, the U-shaped associations observed between TIB and sleep quality are not fully explained by the recorded variables.

4.3. U-shaped associations between TIB and physical and mental health

The associations between TIB and physical and mental functioning were U-shaped, with one exception of poor mental health among females in which only short TIB was associated with poor mental health. The U-shaped associations were explained the most by sleep quality characteristics, followed by work and family characteristics. Behavioral characteristics and long-standing illnesses hardly explained the U-shaped associations.

The differential contributions of each characteristic to the U-shaped associations may be partly attributable to the differences in the combined effects of the associations between TIB and work, family and behavioral characteristics, and by the associations between these characteristics and physical and mental health. The largest reduction observed after adjustment for sleep quality characteristics may be attributable to the fact that the association between TIB and overall sleep quality exhibited a clear U-shaped pattern in this study and that overall sleep quality was found to be significantly and moderately associated with poor physical and mental functioning in our previous study [18].

Work and family characteristics were the second most important factor in explaining the short TIB component of the U-shaped association between TIB and health in this study. This may be explained by the fact that stressful work and family characteristics were more prevalent among those with short TIB in this study and because there were significant associations between these characteristics and poor physical and mental functioning in our previous study [12]. However, work and family characteristics had limited value in explaining the long TIB side of the U-shaped association. This can be explained by the fact that stressful work and family characteristics were less frequent among those with long TIB than among those with average and short TIB in this study.

In contrast, behavioral characteristics and long-standing illnesses hardly explained the U-shaped relationship. This can be explained by the fact that some degree of association between behavioral characteristics and TIB was observed in this study, although the associations between behavioral characteristics and poor sleep and poor physical and mental functioning were relatively small in our previous study [15]. Although long-standing illnesses were found to be moderately associated with poor sleep quality and poor physical and mental functioning in our previous study [11,12], the association between TIB and long-standing illness was not strong; therefore, the influence of long-standing illnesses on the associations between TIB and poor physical and mental health may be limited.

Many previous studies have examined whether sleep hours are associated with an increased risk for health problems, such as cardiovascular diseases, depression, and mortality, independent of other known psychological and biological risk factors [1–3]. However, there is a lack of previous studies on how work, family, and behavioral characteristics influence sleep and physical and mental health, and on which characteristics are most important in terms of the association between sleep hours and health. This study's contribution to the literature is that poor sleep quality is the largest contributor to poor physical and mental health among those with short TIB. In addition, work and family life are more important factors than behavioral characteristics and long-standing illnesses in working populations.

4.4. Methodological limitations

This study was a cross-sectional study; therefore, it could not be used to determine the causal nature of the associations between physical and mental functioning and age, work, family and behavioral characteristics, sleep quality and quantity, and long-standing illnesses. Longitudinal research is required to confirm the causal nature of these associations.

Second, there are limitations attributable to the statistics used in this study. We used a relatively large number of variables when making adjustments. Therefore, overadjustment, adjustment using a variable on the pathway from TIB to health, may have occurred. If this is the case, the significant reductions observed in the U-shaped associations with health following adjustment for sleep quality measurements may be, in part, explained by the overadjustment. Also, although the findings from this study may be biologically explainable, a number of statistical tests were performed in this study which may have increased the chance results.

Third, all the measurements including work, family, behavior, sleep and health in this study were self-reported, although many of these measures are valid and reliable measures [11,24,31] and have often been used in large epidemiological studies [19,21,23]. In future research, more objective measures should be used.

5. Conclusions

Both those with short and long TIB have health risk factors and poor sleep quality; however, the types of risk factors differed between those with short and long TIB in this study. Whereas high job demands, long work hours and a high level of work–family conflict tended to be more prevalent among those with short TIB, those with long TIB had daily drinking habits. In addition, those with short TIB had poor subjective sleep quality and daytime dysfunction, whereas those with long TIB had long sleep latency, poor sleep efficiency, and sleep disturbances. The U-shaped associations between TIB and poor physical and mental health may be largely explained by the U-shaped associations between TIB and sleep quality characteristics, followed by work and family characteristics. Behavioral characteristics and long-standing illnesses hardly explained the U-shaped associations. The policy implications of this study may be that reducing psychosocial stress at work, including implementing family-friendly policies, is beneficial for obtaining adequate TIB and resultant better sleep quality, leading employees to have better physical and mental functioning.

Funding sources

The Japanese Civil Servants Study was supported by grants from the Ministry of Health, Labour and Welfare, the Japanese Society for the Promotion of Science (24590787), the Occupational Health Promotion Foundation, the Univers Foundation (98.04.017), the Daiwa Anglo-Japanese Foundation (03/2059), and the Great Britain Sasakawa Foundation (2551).

Conflicts of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2014.04.012.

Acknowledgments

We are indebted to all the local government civil servants for their participation in this study and also to Ms Yasuko Yamazaki, Ms Yoriko Yoshida and Ms Noriko Annen for their valuable clerical support.

References

[1] Hammond EC. Some preliminary findings on physical complaints from a prospective study of 1064004 men and women. Am J Public Health Nations Health 1964;54:11–23.

[2] Grandner MA, Drummond SPA. Who are the long sleepers? Towards an understanding of the mortality relationship. Sleep Med Rev 2007;11:341–60.
[3] Grandner MA, Hale L, Moore M, Patel NP. Mortality associated with short sleep duration: the evidence, the possible mechanisms and the future. Sleep Med Rev 2010;191:191–203.
[4] Chen HC, Su TP, Chou P. A nine-year follow-up study of sleep patterns and mortality in community-dwelling older adults in Taiwan. Sleep 2013;36:1187–98.
[5] Grandner MA, Jackson NJ, Pak VM, Gehrman PR. Sleep disturbance is associated with cardiovascular and metabolic disorders. J Sleep Res 2012;21:427–33.
[6] Patel SR, Malhotra A, Gottlieb DJ, White DP, Hu FB. Correlates of long sleep duration. Sleep 2006;29:881–9.
[7] Stranges S, Dorn JM, Shipley MJ, Kandala NB, Trevisan M, Miller MA, et al. Correlates of short and long sleep duration: a cross-cultural comparison between the United Kingdom and the United States. Am J Epidemiol 2008;168:1353–64.
[8] Bosma H, Marmot MG, Hemingway H, Nicholson AC, Brunner E, Stansfeld SA. Low job control and risk of coronary heart disease in Whitehall II (prospective cohort) study. BMJ 1997;314:558–65.
[9] Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Systematic review of psychosocial factors at work and private life as risk factors for back pain. Spine 2000;25:2114–25.
[10] Paterniti S, Niedhammer I, Lang T, Consoli SM. Psychosocial factors at work, personality traits and depressive symptoms. Longitudinal results from the GAZEL Study. Br J Psychiatry 2002;181:111–17.
[11] Sekine M, Chandola T, Martikainen P, Marmot M, Kagamimori S. Work and family characteristics as determinants of socioeconomic and sex inequalities in sleep: the Japanese civil servants study. Sleep 2006;29:206–16.
[12] Sekine M, Chandola T, Martikainen P, Marmot M, Kagamimori S. Socioeconomic inequalities in physical and mental functioning of Japanese civil servants: explanations from work and family characteristics. Soc Sci Med 2006;63:430–45.
[13] Kripke DF, Brunner R, Freeman R, Hendrix SL, Jackson RD, Masaki K, et al. Sleep complaints of postmenopausal women. Clin J Women's Health 2001;1:244–52.
[14] Grandner MA, Kripke DF. Self-reported sleep complaints with long and short sleep: a nationally representative sample. Psychosom Med 2004;66:239–41.
[15] Sekine M, Nasermoaddeli A, Wang H, Kanayama H, Kagamimori S. Spa resort use and health-related quality of life, sleep, sickness absence and hospital admission: the Japanese civil servants study. Complement Ther Med 2006;14:133–43.
[16] Buysse DJ, Reynolds IIICF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193–213.
[17] Heslop P, Smith GD, Metcalfe C, Macleod J, Hart C. Sleep duration and mortality: the effect of short or long sleep duration on cardiovascular and all-cause mortality in working men and women. Sleep Med 2002;3:305–14.
[18] Sekine M, Chandola T, Martikainen P, Marmot M, Kagamimori S. Explaining social inequalities in health by sleep: the Japanese civil servants study. J Public Health 2006;28:63–70.
[19] Sekine M, Chandola T, Martikainen P, Marmot M, Kagamimori S. Socioeconomic inequalities of physical and mental functioning of British, Finnish and Japanese civil servants: role of job demand, control, and work hours. Soc Sci Med 2009;69:1417–25.
[20] Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika 1951;16:297–334.
[21] Chandola T, Martikainen P, Bartley M, Lahelma E, Marmot M, Michikazu S, et al. Does conflict between home and work explain the effect of multiple roles on mental health? A comparative study of Finland, Japan, and the UK. Int J Epidemiol 2004;33:894–902.
[22] Doi Y, Minowa M, Okawa M, Uchiyama M. Development of the Japanese version of the Pittsburgh Sleep Quality Index. J Psychiatry Treat 1998;13:755–63. in Japanese.
[23] Doi Y, Minowa M, Okawa M, Uchiyama M. Prevalence of sleep disturbance and hypnotic medication use in relations to socioeconomic factors in the general Japanese adults population. J Epidemiol 2000;10:79–86.
[24] Doi Y, Minowa M, Uchiyama M, Okawa M, Kim K, Shibui K, et al. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) in psychiatric disordered and control subjects. Psychiatry Res 2000;97:165–72.
[25] Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. Sleep 2010;33:585–92.
[26] Meijer AM, Habekothe HT, Van den Wittenboer GLH. Time in bed, quality of sleep and school functioning of children. J Sleep Res 2000;9:145–53.
[27] Ware JE SF-36 health survey manual & interpretation guide. Boston: New England Medical Center, The Health Institute; 1993.
[28] Ware JE, Kosinski M, Keller SD SF-36 Physical & Mental Health Summary Scales: a user's manual. Boston: New England Medical Center, The Health Institute; 1994.
[29] Fukuhara S, Ware JE, Kosinski M, Wada S, Gandek B. Psychometric and clinical tests of validity of the Japanese SF-36 health survey. J Clin Epidemiol 1998;51:1045–53.
[30] Fukuhara S, Bito S, Green J, Hsiao A, Kurokawa K. Translation, adaptation and validation of the SF-36 health survey for use in Japan. J Clin Epidemiol 1998;51:1037–44.
[31] Fukuhara S, Suzukamo Y, Bito S, Kurokawa K. Manual of SF-36 Japanese version 1.2. Tokyo: Public Health Research Foundation; 2001 in Japanese.
[32] Hosmer DW, Lemeshow S. Applied logistic regression. New York: Wiley-Interscience; 1989.
[33] Field A. Discovering statistics using SPSS for Windows. London: Sage Publications; 2000.
[34] Sobel ME. Asymptotic confidence intervals for indirect effects in structural equation models. Sociol Methodol 1982;13:290–312.
[35] Ikehara S, Iso H, Date C, Kikuchi S, Watanabe Y, Wada Y, JACC Study Group, et al. Association of sleep duration with mortality from cardiovascular disease and other causes for Japanese men and women: the JACC study. Sleep 2009;32:295–301.
[36] Ohayon MM. Interactions between sleep normative data and sociocultural characteristics in the elderly. J Psychosom Res 2004;56:479–86.
[37] Hicks RA, Youmans K. The sleep-promoting behaviors of habitual short- and longer-sleeping adults. Percept Mot Skills 1989;69:145–6.
[38] Morin CM, Mimeault V, Gagné A. Nonpharmacological treatment of late-life insomnia. J Psychosom Res 1999;46:103–16.